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ABSTRACT

Increases in the cost of travel together with projected decreases in the cost of long distance telephone calls indicate that economy in consultation can be increased by a shift to more telephone consultation in the future. This may be difficult and awkward for researchers if consultation involves looking at computer output, particularly in an interactive mode. This might be solved if both parties had a terminal. A test of the technical feasibility of such a conference was made. It indicated that on-line consultation is technically feasible and appears to be easy with the APL software system. Several different types of consultation sessions are described. (Author)

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A TEST OF THE TECHNICAL FEASIBILITY OF ON-LINE CONSULTATION USING APL

by

Stan Wilson*

ABSTRACT

Increases in the cost of travel together with projected decreases in the cost of long distance telephone calls indicate that economy in consultation can be increased by a shift to more telephone consultation in the future. This may be difficult and awkward for researchers if consultation involves looking at computer output, particularly in an interactive mode. This might be solved if both parties had a terminal. A test of the technical feasibility of such a conference was made. It indicated that on-line consultation is technically feasible and appears to be easy with the APL software system. Several different types of consultation sessions are described.

KEYWORDS

Telecommunications/transportation vs. communication/ Man-Computer Symbiosis/ consultation and research/ computers and consultation/telephone consultation/computers and research/ APL software system/ interdisciplinary research/

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A TEST OF THE TECHNICAL FEASIBILITY OF ON-LINE CONSULTATION USING APL

I. Introduction

Land grant universities and state agricultural experiment stations are faced, like all state agencies, with rising per unit cost of the items and services they purchase. In order for the same or higher levels of service to be provided these agencies must have increased appropriations. But often there is a resistance to the higher taxes necessitated by increased funding and appropriations do not grow as fast as cost.

Travel expenditures are one of the items increasing in cost. Experiment stations and other agencies must compensate their employees for travel on state business. With increased prices of food, lodging and gasoline these compensations increase. For example, the mileage allotment of the state of Texas is increasing from ten cents a mile to twelve cents as of September 1. Per diem is increasing from sixteen dollars a day to eighteen.[1] It is likely that food and lodging costs will increase even further over the next few years. The prospects of gas shortages seem to guarantee that the price of gasoline will increase also. Thus one may project further increases in per diem and mileage compensation throughout the rest of this decade.

In contrast to the above, the cost of telephone service is projected to decline substantially over the next decade.[2] By 1980 it is predicted that long distance telephone rates will be one-tenth or less

of their current level.[3] A number of states have special agreements with the telephone company to provide long distance service between various state offices located anywhere in the state. These agreements provide for substantially lower long distance rates and may even provide for virtually unlimited communications between certain state offices at fixed rates.[4]

State agricultural experiment stations are strongly affected by increases in travel expenditures. For several reasons it is necessary that experiment stations maintain a system of off-campus stations and centers dispersed throughout the state. Researchers often find that it is desirable or even vital to consult with researchers, statisticians, programmers, system analysis and other specialized support personnel at other locations. One center may not have enough consulting needs to support in-house specialists but several centers might share the time of a statistician or other specialist. In this case he would reside at the main station and travel to centers for consultation or their scientist could travel to the main station.

Given the projected increases in the cost of travel and projected decreases in the cost of long distance telephone calls, it would seem that a shift over to increasing use of the telephone instead of travel for consultation would promote economy.[5] This approach could be taken only if it were possible for consultation to be carried on over the telephone. Often consultation involves viewing numeric data or the numeric results of computer program processing on raw data. If the consultation involves programming help then it might be necessary to examine the actual computer output including a listing of the programs and any error messages. It would appear to be awkward to carry on such consultation using the telephone. The paper containing the data, program listing and

the output of the program would have to be mailed to the individual called on for consultation.[6] This would be particularly awkward and time consuming if the examinations of the output resulted in decisions to have additional computer runs. Two or more days might elapse between runs if the output was sent by mail. (See the discussion of interactive consultation below on pages 9 and 10.)

It would seem possible however, to transport numeric data, program listing and output between sub-stations if each sub-station had a computer terminal. A number of experiment stations are locating terminals at their sub-stations.[7]

II. Procedure and Method[8]

Given the possibility of transferring data and program information between sub-stations, it was necessary to project a specific procedure for attempting to test whether such a tranfer could take place. In addition, the transfer technique would have to be an easy and effective method of consultation. It was believed that the APL software system contained certain features which would allow such a transfer. Therefore, it was decided to use the APL software system in a test.

The specific characteristic of the APL software system which could achieve a transfer was believed to be the APL library system.[9] When an individual acquires an APL account number he may reserve to that number one or more units of on-line storage. These units are called library workspaces. The collection of such workspaces associated with a particular APL number are referred to as the private library of that number. When an individual signs on the APL system he is allocated a section of the computer's main core memory. This section is called his active workspace. In this active workspace all calculations must be performed. If an individual wishes to store the contents of his active workspace on-line

so that he can access it at a later time, he may by giving one simple command, store the content of his active workspace in a workspace of his private library. One may think of this simple command as taking a photograph of his active workspace at that point in time and placing the photograph in his private library. The command does not affect the content of his active workspace. It only puts an exact copy of the content in storage. A second simple command will bring the content back into his active workspace. A third simple command will eliminate a particular workspace when it is no longer needed. In order to refer to a specific workspace in his library, the user must assign a name to that workspace. He does this as part of the command which saves the contents of his active workspace in a library workspace.

In order for different individuals to be able to share programs and data it is possible for one individual to copy the contents of another individual's library workspace if he knows the APL number of the individual whose library workspace he wishes to copy. He may copy the contents of the other individual's library workspace into his active workspace. But this copying will not affect the contents of the other individual's library workspace and he can not eliminate the other indivi-ual's library workspace. It was believed that the ability to copy another individual's library workspace could be utilized to affect a transfer of data, programs and the numeric output of the program run on the data.

At the time of the proposed test two sub-stations at TAES had APL terminals. These were Prairie View, which was fifty two miles from the main station and the Blackland Research Center at Temple, which was seventy-seven miles away. Blackland was chosen. The terminal had been

at Blackland less than six weeks and no organized training in APL had been given to the staff. Yet two researchers were using it to run statistical analysis of thier data.[10] The other terminal taking part in the test was in the Agriculture Building on the Main Campus of Texas A&M (TAMU).

The computer programs selected for the test were a multiple linear regression program (MLR) and a residuals program.[11] Both programs were "canned" routines available on the TAMU APL system. The MLR routine was chosen because it is one of the most frequently used programs and because a number of regressions are often run on the same data. The intention was to fully test the techniques by performing a series of transfers. This would require a series of different outputs. This series of different outputs could most easily and realistically be generated by running a sequence of regressions on the same data but specifying different combinations of variables for each run. The residuals program is often run in conjunction with the MLR program. Finally both programs produce results in the form of easily identifiable but large matricies.

The raw data used consisted of four variables, each of which had ninety-seven observations. The data were inputed at the terminal on the TAMU compus. The observations of two or the variables were transformed by raising them to various powers. This would allow the data to be fitted to non-linear functions and resulted in a data matrix of nine columns (nine variables) and ninety-seven rows (niney-seven observations). Next a telephone call was placed to Blackland and a researcher there signed on the Blackland terminal. The regression and residual programs were run. For the first test the regression program was instructed to use only variables one through seven. The results of the MLR and resi-

duals programs were saved in a library workspace associated with the APL number used to sign on the terminal at the TAMU campus. This took one command. Then the researcher at Blackland was told how to copy the saved library workspace into his active workspace. This took one command and he succeeded on the first try. Next the results of the MLR and residuals programs were printed out on both terminals.

The MLR program produces its results in the form of a matrix with five columns. The number of rows is three more than the number of variables used in the regression. In this first test, with variables one through seven used, the regression matrix would have ten rows. Certain specific values in specific cells of the matricies printed out at the two locations were compared by reading the values over the telephone. Then the residuals matrix was printed out at each location. It contained four columns and ninety-seven rows.

To re-test the procedure, the regression and residuals programs were run three more times. The second time variables one through eight were used. The third time variables one through seven and variable nine were used. The fourth time variables one through nine were used. Each time the regression matrix and the residual matrix were saved in a library workspace associated with the APL number used to sign on at TAMU. Each time the library workspace was copied into the active workspace being used by the Blackland terminal. The second time both the regression matrix and the residual matrix were printed out. The third and fourth times only the regression matrix was printed out. This was done because of the slow speed of the printer and the size of the residuals matrix. Each time the regression matrix was checked to be sure that the latest

one was transferred. These checks showed that all four regression matricies were transferred. This concluded the test. The procedure took less than forty-five minutes.[12]

III. Results and Implications

The successful transfer of the four MLR matricies indicates that on-line transfer of data and results between terminals at distant locations is technically possible using the APL software system. The ease with which it was accomplished indicates that it can be an easy and natural technique for on-line consultation. The test could not demonstrate that it can be an effective method of consultation. For this to be demonstrated the test would have had to be an actual consultation session.[13] During such a session, a more detailed discussion of the numeric output would take place. It is also possible that a consultation would have included a two way transfer of data and/or results. For example, data could be inputed into one terminal, copied into the active workspace of another and used as input for a program. Then the results matrix could be transferred back to the first terminal, printed out on both and then a detailed discussion would occur (see below).

The results of the test do indicate that there is no technical barrier to a two way transfer or a consultation session and it is projected that an opportunity for an on-line consultation session will occur in the near future.[14]

At the present time three distinct types of on-line consultation can be delineated: (1) APL consultation, (2) Statistical consultation and (3) Colleague consultation. In order to indicate the implications of the test, these three types will be described in some detail. To facilitate this description it will be assumed that an individual (called

the researcher) at a sub-station has some numeric data he wishes to use as the input to an APL program. He wishes to discuss this data and the results of the program run with an individual (called the consultant) at the main station or another sub-station. He initiates the consultation with a phone call. Both locations must have APL terminals.

APL consultation consists of aid in running APL programs and giving APL commands. The researcher inputs his data using the terminal and calls up one or more programs, then he initiates the execution of the program on the data. During the run, execution is halted by an error message. He calls a consultant, who, in this case is an individual with more experience and knowledge in APL usage. The researcher also saves his data in one of his library workspaces. The consultant signs on his terminal, copies the data into his active workspace, calls up the program and commands execution of the program on the data. When the error message occurs the consultant is better able to deduce its cause and deal with it because of his greater experience. This solution usually involves a command to branch to another line in the program. The consultant achieves complete execution of the program and saves the results in one of his library workspaces. The researcher copies this library workspace into his active workspace and prints out the results. The consultant explains the error and correction procedure to the researcher so that he is better able to handle it in the future and the session can end there.

Statistical consultation consists of advice as to the appropriate statistical test to run on a set of data and aid in interpreting the implications of the run. The consultant is a statistician. The researcher usually enters his data into the computer system before calling the

consultant. The data are saved in a library workspace of the researcher. They can then be copied by the consultant into his active workspace and printed out if this is deemed desirable. The consultant may have been called in when the experiments were designed. Even if he was, it may be advisable for him to see the actual data which were gathered before a final decision is made about which statistical test to run. It might also be useful if the researcher inputs the data into a program which produces descriptive statistics before contacting the consultant. Then these descriptive statistics as well as, or in place of, the raw data can be passed to the consultant for his opinion.

Once the appropriate statistical operations have been decided on, the researcher can call up a canned routine which performs these and executes the routine on the data. The results, usually in the form of a matrix, can then be saved in his library workspace and copied by the consultant into his active workspace. Then both terminals can print out the results matrix and the researcher and consultant can each examine their copies while they are conferring, over the telephone, on interpretation. Their discussion may produce a decision to execute another type of statistical operation on the data or they may decide to run the same operation but in a somewhat different way. For example, they may decide to run a regression including one or more additional variables or excluding one or more variables. The experiment described in Section II above is an example of this. Once this decision is implemented by running the appropriate program the results matrix can be passed to the consultant's active workspace, printed on both terminals and more discussion can take place based on it. The results of this discussion may be additional program runs. Thus a consultation session

of an hour may consist of a series of runs; each run being based on an examination of the results matrix generated by the previous run. This will be called interactive consultation.

Colleague consultation may be similar to statistical consultation. The consultant would be a member of the researcher's discipline or in the case of an interdisciplinary project a member of another discipline.[15] The program could be statistical or it could be a simulation or model of the particular system under study or it could be a lineary programming routine. The consultation might be interactive. The results of each run would be passed to the active workspace of the individual who did not execute the program. The results would be printed on both terminals and form the basis of a discussion leading to additional runs. The results of these runs would be discussed and lead to further runs. The discussion might also lead to a decision to modify the program. The one executing the runs could then command the necessary program modifications and re-execute the corrected program. The results would be passed to the other active workspace, printed out and used to discuss further runs or modification.

It is unlikely that the various types of usages outlined above have exhausted all possible applications of this technique. Further uses, particularly by different individuals, can be expected to result in additional applications.

FOOTNOTES

[1] An increase of two cents a mile seems small but it is an increase of twenty per cent. The per diem increase is twelve and a half per cent. These figures were provided by Dan Snyder.

[2] These estimates of telephone cost in the future are from Martin (1971). See particularly Chapter 3.

[3] The predictions concerning the drop in telephone rates to one-tenth their size by 1980 is on page 30-31 of Martin (1971).

[4] A good example of this type of agreement is the Texas Agency Network (TEX-AN). This statewide agreement for all state offices is projected to be operational by January 1974.

[5] The idea of replacing transportation by communications is of interest to at least one source of research funding, the National Science Foundation. One of their recent notices (number 45) dated November 24, 1972 and concerned with research in Telecommunications Policy speaks of the tradeoff between transportation and telecommunications. They propose as one of the possible topics of telecommunications research: "Transportation-telecommunications tradeoff: What are the possible tradeoffs between broadband communications and transportation? Applications that have been suggested include teleconferences, electronic mail, decentralization of routine office services. To what extent can the potential for one or more of these areas by investigated theoretically or experimentally in greater detail?"

[6] This would create a delay of at least one day. If the situation required interaction as described on pages 9 and 10 then at least a one day delay would occur between each interaction.

[7] For a description of the use of terminals at sub-stations and other remote locations see the Proceedings of the First International Conference on Computer Satellites in Agriculture.

[8] The method and procedure of the experiment are discussed in extensive detail so that the test can be repeated by other researchers. A repeat of the experiment by independant researchers is vital to an objective determination of the accuracy of the findings. In addition, further test by others will develope other applications not forseen. (See pages 7,8,9, and 10.)

[9] A good description of the APL library system is given in Gilman (1970), pages 95-113.

[10] These researchers are Dr. Gerald F. Arkin and Dr. Lloyd B. Fenn. They had been provided with printed material on APL and had

been shown how to sign on. Dr. Fenn was the researcher on the Temple terminal during the experiment described on pages 5, 6 and 7. During part of the experiment Dr. Arkin was also in the room at Temple. The author was operating the terminal on the TAMU campus during the experiment.

[11] For a description of the MLR program and the residuals program see Smillie (1968), pages 28,29.

[12] The savings which are possible include not only the difference between the cost of travel and the cost of telephone service but also a savings in professional time. During the time a staff member is traveling to and from a remote location he is usually not able to do any useful work, particularly if he is driving. The travel time from College Station to Temple is about two hours. Thus for an hour of consultation an individual would have to spend four hours driving. The mileage cost alone to Temple and back is $15.40 at 10 cents a mile. A WATS call to Temple which lasts an hour would cost $ 3.72 . Thus the hour conference over the telephone is substantially cheaper. For on-line consultation the additional expense involves two terminals in operation for an hour and this would cost a minimum of four dollars. The difference might be eliminated if the individuals used a great deal of computer time, but this would require that they use approximately a minute and a half of computer time and such an amount is not likely when one is running canned programs on APL. It seems probable that the savings in professional time will be of overwhelming significance compared to the savings in mileage and per diem. But it might be more difficult to quantify the savings in professional time. Studies of all types of possible savings should be made and may be the next logical step.

[13] The human element is vital in determining whether this is an effective method of consultation. For some it will be and for others it will not. The difference will probably depend on personality. Some will adapt this method quickly and others will wait until it is in more general use.

[14] It is important that actual consultation be tested several times and by different individuals before this procedure is universally adopted as a partial alternative to travel. Independant tests are facilitated by a detailed description of the procedure (See footnote 8).

[15] For a discussion of the interrelationship between interdisciplinary research, communications and the computer see Billingsley (1972).

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